IMPROVED REDUCING MACHINE ROTOR ASSEMBLY AND METHODS OF CONSTRUCTING AND OPERATING THE SAME

This application claims the priority of provisional application Serial No. 60/203,241 filed May 8, 2000 and the priority of provisional application Serial No. 60/246,862 filed November 8, 2000. This invention relates to rotor assemblies for heavy machinery such as hammer mills and wood hogs for fragmenting waste wood and other products, including demolition debris, stumps, pallets, large timbers, and the like into particulate or chips which are useful, for example, as mulch, groundcover, and fuel.

BACKGROUND OF THE INVENTION

The present invention is directed to an improved rotor construction of rugged and durable character. The present assignee owns U.S. Patent 5,713,525, issued February 3, 1998, for a typical wood hog machine and U.S. Patent 5,419,502, issued May 30, 1995, for a typical tub grinder hammer mill system. Both patents are incorporated herein by reference. The rotor assembly of the present invention is usable with either type of machine. A cutter tooth assembly for such machines is also disclosed in U.S. Patent 3,642,212 (also incorporated herein by reference), issued February 15, 1972, for a cutter tooth assembly for such grinders or fragmenters.

Such machines, which usually comprise a rotor

having a plurality of teeth that pass through openings formed in anvils or the like, and wear rapidly, must be replaced frequently. As the teeth of the rotor wear, their cutting edges become rounded or blunted and less effective in their grinding or cutting function. When in use in the field, a considerable supply of replacement cutting teeth must be maintained.

The present rotor assembly is particularly constructed to overcome some of the difficulties experienced with prior art machinery and utilizes longer lived cutters. The construction in some forms also utilizes deflecting lobes or humps which extend radially and new methods of constructing rotor assemblies.

SUMMARY OF THE INVENTION

A fragmenting rotor assembly for waste wood and other fragmentable material incorporates a drive shaft mechanism and a series of radially projecting axially spaced adjacent hammers situated along the axis of the shaft mechanism and powered by the shaft mechanism. Replaceable knives are removably secured to the leading portions of the hammers and these knives have axially extending radially outer edges on the outermost portions of the knives. The knives, in one aspect of the invention are double edged and lobes or humps may be provided which extend radially sufficiently to deflect material tending to impact the secondary cutting edges.

Those lobes in the radial plane of the hammers,

have outer ends rotating in a circumferential path lying radially short of the circumferential path of the radially outer edges of the knives, but radially beyond the secondary inner edges. In another version of the invention, useful on tub grinders particularly, the knives are single edged. In still another portion of the disclosure the hammers are tilted radially forwardly and the knives have axially overlapping rotary paths of travel.

One of the prime objects of the invention is to provide an aggressive cutting and fragmenting assembly which will operate for a prolonged time in heavy wear conditions.

Another object of the invention is to provide a hammer and knife assembly which is relatively inexpensive to manufacture and which has knife edges which will withstand considerable compressive impact forces and resist fracture.

Still another object of the invention is to provide an assembly of the character disclosed wherein the knives are protected by deflecting lobes provided on the shaft mechanism radially between the hammers.

Other objects and advantages of the invention will become apparent with reference to the accompanying drawings and the accompanying descriptive matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The presently preferred embodiment of the

invention is disclosed in the following description and in the accompanying drawings, wherein:

Figure 1 is a schematic plan view of the rotor assembly;

Figure 2 is an end elevational view thereof:

Figure 3 is a schematic end elevational view of a single rotor disc only with pairs of hammers and lobes mounted thereon;

Figure 4 is a front elevational view of one of the cutter knives only prior to its coating with wear material;

Figure 5 is an end elevational view thereof;

Figure 6 is an opposite end elevational view thereof;

Figure 7 is a top plan view thereof;

Figure 8 is a schematic front elevational view of the cutter knife shown in Figure 4 with the wear surfaces shown as applied thereto;

Figure 9 is an end elevational view thereof;

Figure 10 is a top plan view thereof;

Figure 11 is a face elevational view of one of the lobes which mount radially between the hammers;

Figure 12 is an end elevational view thereof;

Figure 13 is a face elevational view of one of the endmost lobes;

Figure 14 is a sectional elevational view taken on the line 13-13 of Figure 13;

Figure 15 is an end elevational view of one of the rotor end plate deflect inserts;

Figure 16 is a cross-sectional view thereof taken on the line 16-16 of Figure 15;

Figure 17 is a schematic side elevational view of one of the deflect inserts which has been wear material coated;

Figure 18 is an end elevational view thereof;

Figure 19 is a fragmentary plan view of one end of the rotor shaft assembly showing the locking plate in rod locking position, certain parts of the assembly being omitted in the interests of clarify;

Figure 20 is an end elevational view thereof;

Figure 21 is an exploded reduced scale plan view of parts illustrated in Figure 19;

Figure 22 illustrates an unlocked position of the locking plate;

Figure 23 is a schematic side elevational perspective view of a modified rotor assembly, certain parts being omitted in the interests of clarity;

Figure 24 is an enlarged end elevational view;

Figure 25 is a plan view;

Figure 26 is a fragmentary end elevational view of one of the rotor disc assemblies only;

Figure 27 is a reduced size end elevational view showing deflector elements in the angular relationship in which they are used in the rotor

assembly;

Figure 28 is an enlarged side elevational view illustrating another embodiment of a hammer and knife assembly;

Figure 29 is a top plan view thereof;

Figure 30 is a front elevational view;

Figure 31 is an enlarged side elevational view of the rotor body only;

Figure 32 is a front elevational view;

Figure 33 is an enlarged side elevational view of the knife employed, prior to application of its front end surface coating;

Figure 34 is a top plan view thereof;

Figure 35 is a schematic side elevational view of the knife after application of the coating to its front end;

Figure 36 is a top plan view thereof;

Figure 37 is a front end elevational view; and

Figure 38 is a fragmentary perspective view;

Figure 39 is a fragmentary schematic plan view of a modified rotor assembly with hammers shown out of position to illustrate how the paths of the knives axially overlap in rotary travel;

Figure 40 is an enlarged schematic fragmenting and elevational view showing only a set of hammers;

Figure 41 is an enlarged side elevational view of a modified hammer used on one side of a rotor disc;

Figure 42 is an end elevational view thereof;

Figure 43 is a view similar to Figure 41 of the hammer used on the other side;

Figure 44 is an end elevational view thereof;

Figure 45 is an enlarged side elevational view of a modified spacer screening element;

Figure 46 is a schematic enlarged fragmentary plan view, showing an out of position hammer, which illustrates overlapping travel paths, in broken lines;

Figure 46A is a similar view illustrating path overlap; and

Figure 47 is a schematic diagram illustrating hammer and spacer disposition along the axial length of the rotor assembly.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now more particularly to Figures 1-47 of the accompanying drawings and in the first instance to Figures 1-3, the rotor assembly illustrated is generally designated RA and comprises a shaft 10 which may have a keyway 10a by means of which it is coupled to a drive motor. Typically the drive, in addition to keyway 10a, may comprise sprockets and chains, or sheaves and belts, coupled to a drive motor such as a diesel engine. The rotor assembly RA in all embodiments to be disclosed may be employed in either the hammer mill disclosed in the aforementioned patent 5,419,402 or the wood hog disclosed in the aforementioned patent 5,713,525.

Keyed to an enlarged portion 10c of the shaft 10 as, for example, at 11, are the spacers 12a for axially adjacent discs or rotor plates 12 between which radially opposite hammer bodies 13 may be mounted on circumferentially spaced axially extending rods R

extending through opening 13a in the hammer bodies and 13b in the discs 12. In the embodiment shown, discs or plates 12 will have six circumferentially spaced openings 13b to snugly receive the mounting rods R. Figures 19-22 illustrate the manner in which the rods R are releasably locked in position and will later be specifically described. The hammer bodies 13 (Figure 3) include cutter mounting, radially outer head portions 14 having leading faces 14a extending generally radially to the direction of rotation x of the rotor shaft, and trailing faces 14b.

Fragmenting or cutting dual edge knives, generally designated 15, to be later described in more detail, are secured to the hammer heads 14 by suitable fastening mechanism such as a pair of bolts 16 which extend through bolt openings 16a in the cutters 15 and 16b in the hammer heads 14 to be secured by nuts 17. It will be noted that the hammer head sides and top or outer surfaces are coated with bands of a wear material such as tungsten carbide 18.

Referring now more particularly to Figures 1

and 4-7, it will be noted that the cutters, generally designated 15, are provided with radially outer and radially inner fragmenting or cutting edges, generally designated 19 and 20 respectively. The radially outer edges coact with the usual anvil edge A (Figure 1) to and fragment the material. Each of these cutting edges 19 20 includes a radially constant portion 21 (Figure 4) and a radially inclined portion 22, but, as will be seen, the inclined portions 22 of the respective cutting edges 19 and 20 incline in opposing directions. Typically, the edge portion 21 (Figure 4) may be a half-inch in length when the overall axial width of the cutter is 4 inches. It will be noted that the cutter body is counterbored as at 23 to receive the heads of bolts 16. The angle of inclination of inclined portions 22 may typically be 12° to the surfaces 21.

In Figure 4, the grinding of the edges 19 produces a relief face 24 on the cutter body and the grinding of the edges 20 produces a like face 25. The relief angle of inclination of the faces 24 and 25 may typically be 28°. It will also be seen that the end edges 21 and 20 are relieved as at 19a and 20a and this angle of relief may typically be 8°. As Figures 8-10 indicate, the cutters are also provided with a welded-on wear material which is coated on them as shown in Figures 8-10 at 26.

Referring particularly to Figure 1, it will be

noted that the hammers on adjacent discs or rotor plates 12 are offset angularly with respect to one another in helically staggered relation and that the edges 19 and 20 project axially beyond the hammer head portions 14 partially across the intervening spacers 12a. Thus, the portions 21 of the edges 19 and 20 on axially adjacent hammerheads at their extreme axially projecting edges revolve in closely adjacent paths of revolution, so that no appreciable space is left between these paths axially. These edges 19 and 20 on the axially adjacent cutters which are circumferentially closest (adjacent) are oppositely inclined as shown at a and b in Figure 1. Because of this, the wood fragments are not progressively forced axially left or right and tend to remain more uniformly dispersed over the length of the cutter head assembly. It will also be observed that the cutters 15 on the axially aligned hammers 13 have outer cutting edges which incline in opposing directions to provide a more aggressive fragmenting action. In each instance, however, there are inner edges 20 which are basically held in reserve so that, when the time comes, the knives 15 may simply be rotated 180° once the bolts 16 are removed. The former inner edges will then become the outer "working" edges.

Lobes or humps 27 of generally delta shape are provided as shown particularly in Figure 3. These lobes 27 are situated radially between the hammer bodies 13.

The inner ends of lobes 27 are curvilinear as at 27a to conform to the circumference of the disc hubs 12a. As shown in Figures 11 and 12, rod openings 29 are provided in the lobes 27. The distance between a rod opening 29 and one of the openings 13a is the same as the distance between the pair of openings 13a in each hammer 13 so that rods R, mounted or supported by discs or plates 12, mount both the hammers and the lobes in radial alignment, as Figure 2 indicates.

The interior lobes 27 are configured as shown in Figures 11 and 12. The endmost lobes, at each end of the rotor assembly, are designated 30, and likewise have openings 29 to receive and pass the mounting rods R. They also, however, are provided with openings (Figures 13 and 14) comprising bores 32 and counterbores 33. Provided to be received in the openings are screening or deflecting inserts, generally designated 35 (see Figures 15 through 18), which comprise square shaped bodies 35a which have wear surface-coated sides 36 as shown. The bodies 35 have cylindrical portions 35b which are received in one of the openings 33 and can be secured by screws extending from the opposing opening 33 and threaded into bolt openings 38 in inserts 35.

As Figure 1 particularly points out, the purpose of the inserts 35 is to project axially across the rod-locking end plate assemblies generally designated EP and furnish wear material coated surfaces for engaging

the work and radially protecting or screening the end plate assemblies EP.

Referring now to Figures 19-22, each end plate assembly EP includes an end plate 39 having an outwardly facing cavity or recess 40 in which a locking plate or ring disk 41 is received for limited rotary adjustment. The end plates 39 have bores 42 for passing rods R and locking plates 41 having identically circumferentially spaced bores 43 which in the rod-releasing position (Figure 22) can be aligned with bores 42. Figure 20 illustrates a rod-locking position in which the locking plates 41 have been rotated slightly to block endwise removal of the rods R. Circumferentially spaced bolts 44 projecting endwisely through end plates 39 also pass through arcuate slots 45 and have nuts to fix the rotary adjustment of the locking plates 41. It will be seen that the ends of shaft 10 have threaded portions 46 which releasably receive lock nuts 47 for fixing the plates 39 in locked position.

In operation, the assembled rotor assemblies are provided in either a wood hog or a hammer mill, such as a tub grinder hammer mill, for example, and driven in the direction of rotation <u>x</u>. When the outer radial edges 19 of the cutters 15 require resharpening, the bolts 16 are removed and the cutters 15 are turned end-for-end to dispose the former inner edges 20 radially outwardly. Obviously, other cutters 15 will be carried in inventory

so that the need for trips to the cutter resharpening station is minimalized. The cutting edges 19, which are outermost and incline in opposite directions on radially in-line hammer heads 14, provide an aggressive cut in a fragmenting operation which is not as well achieved if the edges have no inclined portions 22. With the provision of portions 21, however, there are no points to be readily worn or rounded, as if the edges 22 were to extend from end-to-end of the cutters 15.

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The paths of rotation of the outer knife cutting edges is shown at "y" in Figure 3. The paths of the outer edges of the lobes 27 is shown at "z". It is to be noted that the outer edges of lobes 27 traveling in the paths "z" radially protect the inner edges 20 of each cutter knife 15 during operation, along with also protecting or screening the bolts 16 which hold the cutters 15 in fixed position. Because of the disposition of the lobes 27 on discs 12 in the same radial plane as the knives, wood fragments which might otherwise impinge upon the inner edges 20 and the bolts 16, are deflected in substantial part by the lobes 27.

A further assembly, which is modified in several respects, is disclosed in Figures 23-27. Where the parts or assemblies are substantially the same as previously described, the same numerals and letters have been used to designate them.

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In Figure 25, for example, the overall rotor

assembly is similar to the rotor assembly RA disclosed in Figure 1, and the hammer assemblies 13 are identical. The rotor assembly RA operates in conjunction with an anvil A of the character disclosed in Figure 1 and rods R, as previously, are used to mount the hammer bodies 13 and associated knives 15, in assembled position. The hammer body openings 13a are, as previously, provided along a circle "c" having a constant radius taken from the axis of shaft 10. In the rotor assembly of Figures 23-27, however, there are no spacer plates 12 and, as Figure 25 indicates, the fragmenting and cutting edges 19 and 20, which are provided on hammer heads 13, project axially beyond the hammerhead portions 14 to partially axially lap one another. The edges 19 and 20 on the axially adjacent cutters, which are circumferentially closest (adjacent), are not inclined. The cutter head assembly RA, as previously, includes the rod-locking end plate assemblies EP, including end plates 39 which mount the ends of rod R and the locking plates 41 which lock the removable rods R in position.

In the prior described rotor assembly, the lobes or humps 27 of generally delta-shape have curvilinear surfaces 27a which are received by the spacer disc hubs 12a. In the present case, the delta-shaped lobes are replaced by dual deflector lobe members, generally designated 48, having keyways 49 or 53, which may secure them on the shaft 10 by way of appropriate

keys. Rods R similarly extend through the openings 50 provided in 180° spaced apart relation along circle "c" in the members 48. It will be noted that the members 48 are shaped such as to provide curvilinear surfaces 51 which match the curvilinear surfaces 13b of the hammer bodies 13 on which they are received, and that the screening members 48 are also provided with radially outer lobes 52 having outer peripheral deflecting surfaces 52a. The deflector lobe members 48 have substantially the same axial width as the hammer bodies 13 and it will be noted that the peripheral surfaces 52a have the path of rotation previously identified by the letter "z" in Figure 3 and radially protect the inner edges 20 of each cutter 15 during operation, along with also protecting or screening the bolts 16 which hold the cutters 15 in fixed position.

Figure 27 illustrates the staggered relationship of axially successive deflector lobe members 48. It will be noted that the parts 48 are identical, with the exception that the horizontal disposed member or element 48 at the right end of Figure 27 differs in the configuration of its keyways 29 from the keyway shapes 53 shown in Figure 27, which, of course, require axially extending keys of the same configuration to mount them on the shaft portions 10c.

In operation, the cutter head assembly, disclosed in Figures 23-27, may also be used in either a

wood hog or a hammermill, with the hammer bodies operating in exactly the same manner as previously. With the circumferential path of rotation of the surfaces 52a, wood fragments which would otherwise impinge upon the inner edges 20 and the bolts 16 are deflected in substantial part by the dual deflector lobe members 48.

Figures 28-37 are directed to another hammer knife assembly in which, again, like parts have been identified by the same numerals and letters as previously. In this construction, the front or leading face of each hammer head 14, generally designated 54, is formed with a radially inwardly inclined support surface 55 (Figure 31) which, for example, can extend at an angle of 125° to the vertical in this figure. A tool base supporting surface 56 leads from surface 55 and can extend at 90° to the surface 55 in Figure 31. The recessed configuration 54 also includes a vertical surface 57 in Figure 31, and a clamping surface 58 which, for example, can extend at 128° to the surface 57.

As Figure 28 illustrates, it is the surfaces 55 and 56 which receive the fragmenting or cutting tool, generally designated T, which is provided with a hard surfaced coating 59 for cutting tool edge 60. Figures 33 and 34 illustrate the configuration of the cutting tool T prior to coating, which is shown as a tool bar in Figures 33 and 34 which is cut away at an angle of, for example, 45° from its upper surface 61 as at 60a to define the

uncoated cutting edge 60. It will be noted that the upper surface 61 of tool bar T is recessed as at 62 at an inclined relief angle of about, for example, 3° from the surface 61 and that the base end wall 63 at its upper end is relieved as at 64.

The hard surface tungsten carbide, or other suitable hard surfaced material, which is applied to the face 60a and cutting edge 60, as shown in Figures 35-38, is about one-eighth inch in thickness. As shown in Figure 35, it coats a major portion of wall surface 60a and the front end of bottom surface 66 to protrude from each. It, likewise, as shown in Figures 36 and 37 projects laterally beyond the side walls 65 of the tool bar as at 65a. It is the flat outer surface 66 of the toolbar, which is engaged by the wedge plate 67 (shown in Figures 28 and 30). Plate 67 has oppositely disposed, similarly inclined wedging surfaces 68 and 69, which respectively engage the toolbar face 66 and the hammer head surface 69 to wedge the toolbar T in rigidly fixed position. A threaded opening 70, provided in wedge plate 67, aligns with a bolt opening 71 through head 14 to receive a bolt 72 which, when revolved in one direction, draws the plate 67 inwardly to tightly clamp toolbar T in position.

In operation, the toolbar T aggressively attacks the wood debris being fragmented or reduced as the rotor assembly RA is revolved at a rapid rate of

speed. By loosening bolt 72 and rotating it in the opposite direction, wedge plate 67 may be backed off to permit the ready substitution of a replacement tool T, when wear makes it necessary.

Figures 39-47 illustrate a still further modified rotor assembly. Where the parts or assemblies are substantially the same as previously shown and described, the same numerals and letters have been used to designate them. As before, the rotor assembly RA operates in conjunction with an anvil (not shown). Its drive shaft 10 is shown as journaled in frame supported bearings B supported by machine frame F, and as being driven by a sheave element, generally designated SH, configured to receive motor drive belts in the usual manner. While not previously shown in the drawings, it is to be understood that all of the rotor assemblies shown herein may be journaled and driven in the manner disclosed in Figure 39.

Sub B7 Fixed in axially spaced relationship along the shaft 10 are a series of rod-supporting rotor discs which are generally designated 72. As Figure 40 indicates, the hammers 14 are provided in 180° spaced relation axially adjacent each of the discs 72, on the rods R, which are replaceably mounted as previously disclosed. In the present instance, however, there are a total of 8 rods disposed in 45° apart circumferential relationship. The rods R are locked in position by the elements disclosed

in Figures 19-22.

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The hammers 14 and knife structures 15 may be of the same constructions as previously set forth in any of the drawing figures with the salient difference in this embodiment, however, that the head portions 14 tilt forwardly, with respect to a radial line rl extending from the axis of rotation "r", in the direction of rotation of the outer knife edge 19. This forward tilt can be readily ascertained by comparing the radial line rl shown in Figure 40 with the like radial line rl shown in Figure 2. Figures 41 and 43 particularly further illustrate this configuration wherein the head portions 14 of the hammers extend at an angle with respect to the hammer body portions 13. Otherwise, the hammers remain effectively the same as those disclosed in the first embodiment of the invention. It has been found that with the hammer head in effect tilting forwardly as disclosed a more aggressive bite is obtained by the tilted knife edges. With respect to the hammers disclosed in Figures 41 and 43, it is to be noted that the body portions 13 include shoulders 73 and that the angle of inclination of the leading face 74 of each of the heads 14 of the modified embodiment extends at substantially an angle of 7° to the radial line rl.

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In Figure 45 a modified form of deflector element or member is disclosed generally at 74. The element 74 may be referred to as generally chain-link

configured and includes openings 75 permitting its mounting on a pair of the circumferentially adjacent rods R in the axial spaces between discs 72 in radial alignment with hammers mounted on the discs 72 and rods R. Element or member 74 also includes arcuate surfaces 76 for enabling it to clear the shaft 10. One of the members 74 is shown schematically in position in Figure 39. It is to be appreciated that each of the pairs or sets of hammers which are essentially of any of the configurations described herein, are disposed 180° apart in the spaces between discs 72 and are successively helically staggered axially. Thus, the position of the respective hammers shown in Figures 39, 46, and 46A in which true axial knife overlap is indicated is never reached. These figures are included to illustrate knife path overlap.

Sub B10 In Figures 39, 46, and 46A, the discs involved in these figures have been designated as 72a and 72b. The hammers involved have been designated as 13A, 13B, and 13C. It will be assumed that in Figure 46A, only the hammer 13A is shown in its true position. Hammer 13B is shown in a broken line position and, of course, would truly be circumferentially displaced from hammer body 13A. However, by showing hammer 13B in a rotated position, it is possible to show the three quarter inch axial path overlap which is achieved.

Sub B11 With particular attention now to Figure 46 and

with the hammer 13A again being shown in its true position, it is possible to show that when hammer 13A is in true position, and hammer 13C is rotated out of true position to the broken line position in Figure 46, an axial path overlap of a quarter of an inch is achieved. This means that the entire axial surface of the work is covered during rotation of the knives, which along the axis r of the rotor have paths of rotation which are entirely axially overlapping, while being displaced circumferentially with respect to one another.

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The diagram, Figure 47, illustrating a further arrangement discloses the various rods designated 1-8 at the left end and illustrates these positions in clockwisely arranged vertical position in the hammer-spacer designation part of the diagram. The hammers of Figures 46 and 46A are indicated by the letters X and the members 74 termed spacers by the letters O in the diagram, and the disposition of the members 74 and hammers is well indicated in the spaces g between the disc representations 72. As will be seen, there is a deflector member 74 indicated at O for each hammer X and they are arranged as indicated in the spaces g between the discs 72 which are numbered 1-18. The disposition of the hammers and spacers 74 circumferentially is portrayed in the diagram. In this embodiment the hammers are not in true radial alignment in the gaps or spaces g.

In operation, the offset tilted hammer heads 14

operate as previously but take a more aggressive bite and the cutting edges have an overlapping path of travel.

The disclosed embodiment is representative of a presently preferred form of the invention, but is intended to be illustrative rather than definitive thereof. The invention is defined in the claims.